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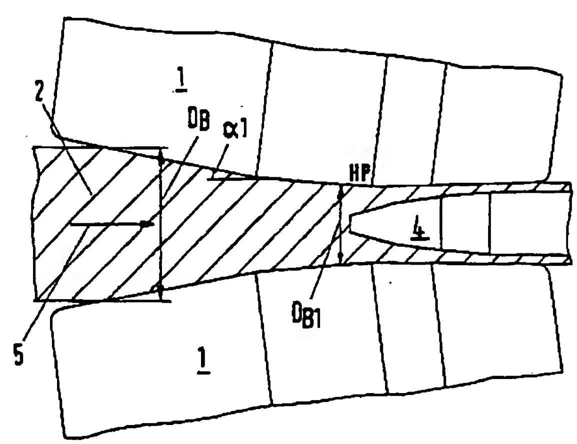
(54) **Process for the production of seamless tube**

(57) The invention refers to a process for the production of hot-finished tube of carbon, alloyed and high-alloy steels, in particular tubing for antifriction bearings, during which pretreated and degassed as well as deoxidised liquid steel of any circular cross-section but the required chemical composition is continuously cast, separated into charge lengths and, following heating to forming temperature, formed in a pipe mill. The continuously cast bloom being preformed in a 3-roll rotary piercing mill through massive reduction and right afterwards being pierced in a 3-roll rotary piercing mill with axially fixed piercing mandrel in order to form a hollow billet.

Fig. 1



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Description

[0001] The invention refers to a process for the production of hot-finished tube of carbon, alloyed and high-alloy steels, in particular tubing for antifriction bearings, during which pretreated and degassed as well as deoxidised liquid steel of any circular cross-section but the required chemical composition is continuously cast, separated into charge lengths and, following heating to forming temperature, formed in a pipe mill.

[0002] Standardised hypereutectoid steels of a high carbon content, known e.g. by the DIN designation 100Cr6, constitute the material used to produce hot-finished tube intended as starting material for the manufacture of individual antifriction bearing rings.

[0003] During conventional manufacture of such tube, at first an ingot is cast and then rolled to a tube round in a roughing mill. This tube round is formed to a hot-finished tube preferably in an Assel mill. Located downstream of a rotary hearth furnace, an Assel mill is usually equipped with a piercing unit in the form of a rotary piercing mill designed to produce a hollow body, which is then fed to an Assel mill with three evenly distributed, grooved peripheral piercer rolls and a bar serving as internal tool. Subsequent to intermediate heating, the hot-finished tube is produced in a multiple-stand reducing mill and a downstream rotary sizer. A drawback of that process is that the size of the tube round employed must be close to that of the hot-finished tube, thus requiring a variety of rolled and/or forged tube round materials to cover the entire product range.

[0004] Besides Assel mills, other pipe mills, such as push bench plants or mandrel mills, are also employed to produce tubing for antifriction bearings, but always with preformed and homogenised charge material.

[0005] It has also been suggested to produce a continuously cast bloom, which is rolled or forged after it has been cut off, in place of an ingot. The rolling or forging process is always preceded by diffusion annealing in order to largely break down or reduce segregations due to the casting process as well as coarse carbide segregations.

[0006] As, last but not least, the processes for starting material production described above are expensive due to the capital-intensive forming equipment, and the multitude of work and transportation stages entail the risk of generating additional faults and/or intensifying existing ones, which then need to be eliminated at extra cost, other processes were searched for.

[0007] From the German generic patent application DE 195 20 833 A1, a process for the production of hot-finished tube made from high-carbon, especially hypereutectoid steel offering a cost advantage over the familiar processes and allowing a better utilisation of the material while reducing processing times has become known. Employment of unformed vertically cast strand or strand cast in a bow-type continuous caster made from steel of any cross-section, particularly steel belonging to the material group of antifriction bearing steels, in a pipe mill without requiring the customary upstream rolling and forging processes or the homogenising treatment necessary according to the state of the art constitutes the essence of this well-known process. Elimination of these work stages results in considerable savings both in terms of time and money, besides an improved utilisation of the material, which does not need to be separated and cropped as often.

[0008] After being separated into charge lengths, the continuously cast bloom produced in accordance with the familiar process is heated to forming temperature without preliminary forming, i.e. as cast, and then supplied to a piercing press, which may be followed by an elongator and a push bench. The state of the art also permits the use of a 2-roll cone-type piercer preceding the mandrel mill or plug rolling mill. The familiar solution only suggests creating a tensile state with a minimised amount of tensile stresses in the workpiece, thus eliminating the risk of having the workpiece burst during the piercing process. It does not, however, specify concrete measures to take in order to minimise those tensile stresses when using a cone-type piercer.

[0009] This, however, would be of special importance in the above case, as especially the 2-roll cross-rolling process it entails is characterised by its high degree of tensile stresses in the area of the billet core which may lead to bursting of the billet core when a solid billet is cross-rolled without an internal tool or with a maladjusted internal tool. This state of stress characteristic of 2-roll cross-rolling as well as the resultant "reeling effect", which causes the core zone to break up and leads to internal surface defects of the rolled hollow billet during 2-roll cross-rolling of unformed 100 Cr 6 cast strand, are adequately described in the technical literature and known to the expert.

[0010] On the basis of the well-known process for the production of hot-finished tube out of high-carbon, especially hypereutectoid steel using unformed cast strand, the invention on hand is intended to offer a solution to minimise the amount of tensile stresses in the core zone of the workpiece or even to avoid them altogether and in this way to eliminate the risk of having the workpiece burst, thus permitting simple production of alloyed and high-alloy steel pipe and tube, in particular high-quality tubing for antifriction bearings, in Assel mills and other pipe mills at a reduced starting material cost.

[0011] To solve the problem, the suggestion is to preform the continuously cast bloom in a 3-roll rotary piercing mill through massive reduction and right afterwards pierce it in a 3-roll rotary piercing mill with axially fixed piercing mandrel in order to form a hollow billet.

[0012] As opposed to the 2-roll cross-rolling process with a stress condition that may lead to bursting of the billet

core due to the high degree of tensile stresses in the billet centre, the 3-roll cross-rolling process only exerts compressive stresses on the billet core, in this way preventing a destruction of the workpiece. The essence of the solution presented by this invention thus consists in using a 3-roll rotary piercing mill to form the continuously cast starting material - in particular 100 Cr 6 - by massive reduction as an indispensable prerequisite to perfect cross-rolling, with the hollow billet needed for stretch-rolling being produced by piercing in the same 3-roll rotary piercing mill during the next work stage.

[0013] As a result of the favourable tensile state of the 3-roll process, the loosened core area of the cast strand does not burst but is rather compacted by the reduction in diameter; subsequent to the massive reduction in diameter, the billet is pierced. One of the features of the invention is that the continuously cast bloom can be both preformed and pierced over an axially fixed piercing mandrel in the same 3-roll rotary piercing mill provided with suitably grooved rolls, consequently considerably simplifying the plant and reducing its price.

[0014] According to this invention, massive reduction and piercing can take place either in one step and in the same rolling direction or - according to another feature of the invention - reversing and in two steps, with reversed direction of rotation of the rolls or reversed roll inclination.

[0015] The two processes need only one powerpack for both forming steps, resulting in low investment cost. A higher tonnage can be achieved by the one-step rolling process, but the two-step rolling process exerts less stress on the workpiece because the diameter development of the roll, provided a tapered roll is used, can be adjusted to that of the workpiece, in this way minimising workpiece twist. For the first step, i.e. for massive reduction, the roll profile is convergent; for the second step, i.e. for piercing, which usually involves a slight expansion of the workpiece, the roll profile is divergent.

[0016] It is also feasible to perform massive reduction and piercing in two steps and on two separate 3-roll rotary piercing mills arranged right behind each other. The drawback of this solution would be a higher investment cost and increased heat losses. Its benefits, however, are the reduced cycle times that can be achieved, as well as the fact that no compromise must be arrived at with regard to the suitability of the roll grooves for both piercing and massive reduction. This renders the process more flexible as to the hollow billet sizes that can be produced.

[0017] It is suggested that massive reduction of the continuously cast bloom prior to the piercing process should amount to 50% to 80% of the initial cross-section.

[0018] We expect positive results of the solution proposed by this invention when the angles α_1 on the inlet side between one surface line of the continuously cast bloom and one surface line of each of the rolls of the 3-roll rotary piercing mill are variable from 3° to 13°, preferably from 10° to 12°. One the one hand, these entry angles ensure that the workpiece can be seized and pulled through, on the other hand the roll will not have to be longer than needed.

[0019] The 3-roll rotary piercing mill needed to implement the process proposed by the invention should preferably be a 3-roll cone-type piercer allowing the diameter development of the roll to be adapted to that of the workpiece. According to the invention, the rolls are moved to a divergent position for piercing and to a convergent position for preforming.

[0020] The invention allows antifriction bearing steel in the form of a directly cast strand to be employed as starting material in an Assel mill. This also applies to high-alloy austenitic-type steels. The high costs previously incurred by the preliminary forming of 100 Cr 6 billets as well as billets of other alloyed and high-alloy steels to tube rounds in roughing mills or forging machines can be avoided. The multitude of different billet sizes needed to produce the customary range of finished sizes of such mills can also be reduced from 5 - 10 billets to 1 - 3 billets; the smallest size range of billets produced by the continuous caster can be increased from 130 to 160 - 180 mm. This permits to cut down on raw material costs, simplifies the continuous casting process and reduces warehousing costs, also due to the savings in tools.

[0021] An example of the design proposed by the invention is illustrated by the drawings and described below. The drawings show,

Fig. 1	Diagrammatic representation of massive reduction and piercing in one step
Fig. 2 and Fig. 3	Reversing massive reduction and piercing in two steps

[0022] Figure 1 shows a diagrammatic cross-section of two of the three rolls of a cone-type piercer, with the rolls designated by 1. The billet, designated by 2, is introduced into the rolling mill in the direction of the arrow (5) and undergoes massive reduction from D_B to D_{B1} up to the mandrel (4). Subsequently, the billet is pierced over the fixed, freely rotatable mandrel.

[0023] Figures 2 and 3 show two steps of the two-step process in accordance with the invention. Figure 2 again represents two of the three rolls (1) of a cone-type piercer, with the billet (2) entering it in the direction of the arrow. The billet undergoes massive reduction from D_B to D_{B1}, with the convergent rolls (1) as tools. Figure 3 shows the billet of the diameter D_{B1} being reversed after massive reduction according to Figure 2, now being pierced over the fixed, freely rotatable mandrel bar (3) with the mandrel (4) in the direction of the arrow by the rolls that are now rotating in

the opposite direction and diverging in rolling direction.

Claims

1. Process for the production of hot-finished tube of carbon, alloyed and high-alloy steels, in particular tubing for antifriction bearings, during which pretreated and degassed as well as deoxidised liquid steel of any circular cross-section but the required chemical composition is continuously cast, separated into charge lengths and, following heating to forming temperature, formed in a pipe mill,
characterised by
the continuously cast bloom being preformed in a 3-roll rotary piercing mill through massive reduction and right afterwards being pierced in a 3-roll rotary piercing mill with axially fixed piercing mandrel in order to form a hollow billet.

2. Process according to Claim 1,
characterised by
the continuously cast bloom being both preformed and pierced in the same 3-roll rotary piercing mill provided with suitably grooved rolls.

3. Process according to Claim 1 or 2,
characterised by
massive reduction and piercing taking place in one step and in the same rolling direction.

4. Process according to Claim 1,
characterised by
reversing massive reduction and piercing in two steps, with reversed direction of rotation of the rolls or reversed roll inclination.

5. Process according to Claims 1 through 4,
characterised by
massive reduction and piercing being performed in two steps and on two separate 3-roll rotary piercing mills arranged right behind each other.

6. Process according to Claims 1 through 5,
characterised by
the massive reduction of the continuously cast bloom prior to the piercing process amounting to 50% to 80% of the initial cross-section.

7. Process according to Claims 1 through 6,
characterised by
the angles on the inlet side between one surface line of the continuously cast bloom and one surface line of each of the rolls of the 3-roll rotary piercing mill being variable from 3° to 13°, preferably from 10° to 12°.

8. 3-roll rotary piercing mill for implementation of the process for the production of hot-finished tube of alloyed and high-alloy steels, in particular tubing for antifriction bearings, during which pretreated and degassed as well as deoxidised liquid steel of any circular cross-section but the required chemical composition is continuously cast, separated into charge lengths and, following heating to forming temperature, formed in a pipe mill,
characterised by
the 3-roll rotary piercing mill taking the form of a cone-type piercer.

9. 3-roll rotary piercing mill according to Claim 8,
characterised by
the possibility to move the rolls to a convergent position for prereduction and to a divergent position for piercing.

10. 3-roll rotary piercing mill according to Claim 8,
characterised by
the possibility to move the rolls to a divergent position for prereduction and to a convergent position for piercing.

Fig. 1

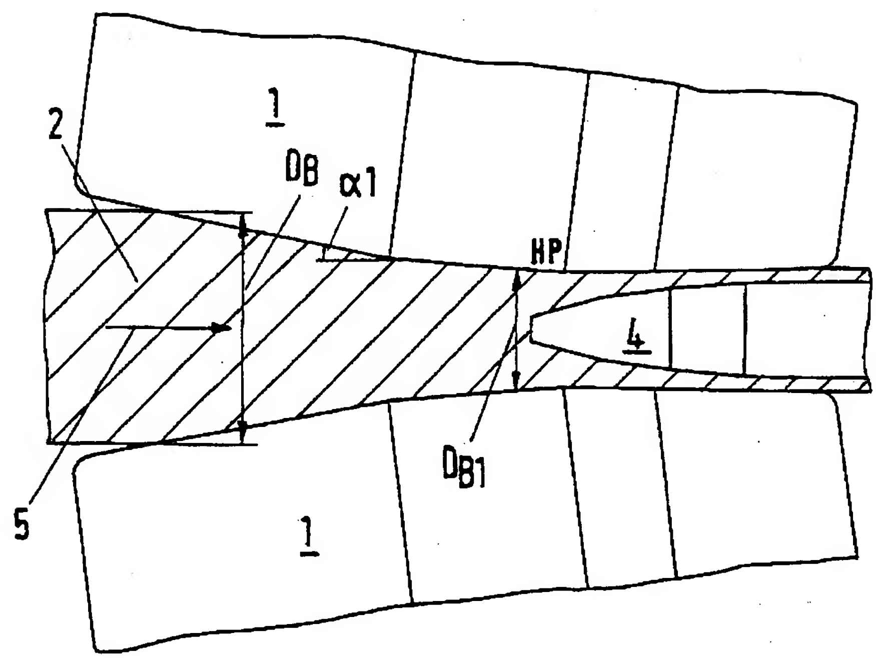

Fig. 2

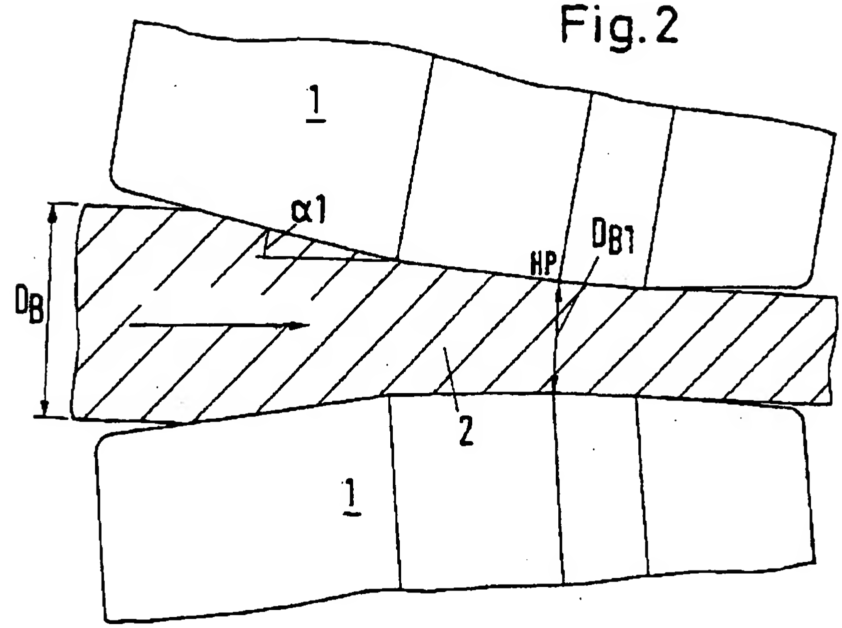

Fig. 3